REMARKS

Claims 46 and 48-56 have been amended, and claims 1-28 and 36-63 are pending in the present application. The claim amendments are supported by the specification and claims as originally filed, with no new matter being added. Accordingly, favorable reconsideration of the pending claims is respectfully requested.

1. First Claim Rejection Under 35 U.S.C. § 103(a)

The following claims:

independent claim 1, and dependent claims 3-5 and 7-11;

independent claim 36, and dependent claims 37-44; and

independent claim 45

stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,847,461 to Xu et al. (hereinafter the "Xu '461 patent") over U.S. Patent No. 6,217,721 to Xu et al. (hereinafter the "Xu '721 patent"). Applicant respectfully traverses.

The Xu '461 patent teaches an integrated circuit structure having an insulating layer 10 formed over integrated circuit structure 2. Openings 14 and 16 are formed in insulating layer 10 and extend downwardly from upper surface 12 of the insulating layer 10 to expose surfaces 4 and 6 of integrated circuit structure 2 at the bottom of the opening 14 and 16. A barrier layer 20 is formed over upper surface 12 and insulating layer 10 as well as over the side walls of openings 14 and 16 and over exposed surfaces 4 and 6 at the respective bottoms of openings 14 and 16. (Col. 3, lines 12-22.) A metal layer 30 comprises a layer of compressively stressed metal which is subsequently extruded down into openings 14 and 16. (Col. 4, lines 17-23.) A cap layer 40 is formed over metal layer 30. Cap layer 40 comprises a high tensile strength material to restrain the upward movement of metal layer 30 during the subsequent extrusion step. (Col. 6, lines 26-34).

The Xu '461 patent further teaches that:

> After cap layer 40 has been formed over compressively stressed metal layer 30, the extrusion step may be carried out . . . by heating the structure to a minimum temperature at which plastic deformation of metal layer 30 will occur, but lower than the melting temperature of metal layer 30. That is, what is desired is a temperature at which compressively stressed metal layer 30 will begin to extrude into openings 14 and 16 to completely fill openings 14 and 16 while avoiding the occurrence and flow of molten metal.

Col. 6, line 66 through col. 7, line 8.

Specifically, the Xu '461 patent is directed to eliminating the need for a seed layer. The Xu '461 patent teaches that:

> [A]s dimensions of lines and contact openings decreased, with ever increasing scale of VLSI structures, problems arose with securing satisfactory filling of the entire contact opening with the aluminum used to form the contact layer over the insulating layer. This, in turn, has given rise to the use of other filler materials such as tungsten to fill the contact opening prior to the formation of the aluminum layer over the insulating layer. After formation of, for example, a barrier layer of TiN, a layer of tungsten is deposited over the barrier layer and insulating layer which also fills the contact opening after which the structure is planarized to remove all of the surface tungsten (leaving only the tungsten in the contact openings). The aluminum layer is then formed over the insulating layer which aluminum layer thereby makes electrical contact with the upper exposed surface of the underlying tungsten in the contact opening.
>
> While this approach has solved the problem of adequate filling of small contact openings with conductive material, the use of tungsten as a filler material results in other problems. Filling the openings with tungsten adds further deposition and planarization steps to the process, resulting in more complexity, more cost, and less reliability. In addition, the use of tungsten metal results in higher particle formation possibilities, higher resistivity of the tungsten compared to aluminum, and a metal interface wherein the crystallographic disposition of the tungsten can, in turn, affect the crystallographic form of the aluminum subsequently deposited therein, i.e., by the tungsten surface providing a seed surface for the aluminum deposition, thereby sometimes resulting in the subsequent formation of a less desirable crystallographic form of aluminum. It would, therefore, be highly desirable to be able to fill very small diameter openings in an insulation layer with metal such [as] aluminum initially deposited on the surface of the insulating layer and then later patterned to form a metal interconnect layer, i.e., to use the same metal to both fill the openings in

the insulation layer and to form the electrically conductive interconnect or wiring harness on the surface of the insulating layer.

Col. 1, line 56 through col. 2, line 27 (emphasis added). Thus, the Xu '461 patent specifically teaches that a seed layer is undesirable when filling small openings and is directed toward other methods of filling the contact openings as described above. Clms. 4, 18

Despite the explicit teaching of the Xu '461 patent against the use of a seed layer, the Office Action asserted that the Xu '721 patent teaches the step of forming a seed layer on a diffusion barrier layer. The Office Action asserted that it would have an obvious to one of ordinary skill in the art at the time the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer, and having the thermal properties as taught by the Xu '461 patent, since heating the barrier layer in the nitrogen environment substantially reduces the electronic barrier at the metal semiconductor interface and the addition of titanium nitride as the seed layer improves the flow of aluminum into an interconnect at moderate temperatures.

"To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation ... to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations." Furthermore, the "teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure." (citations omitted) M.P.E.P. §§ 2142, 2143, pp. 2100-121, -122 (8th ed., Aug. 2001).

The combination of the Xu '461 patent and Xu '721 patent is improper because the Xu '461 patent specifically teaches away from the use of a seed layer when extruding conductive material into very small contact openings. Thus, one of skill in the art would not be motivated to apply a seed

layer under the metal layer 30 of the Xu '461 patent in view of the fact that a seed layer is specifically taught against.

Accordingly, claims 1, 36 and 45 would not have been obvious over the cited references since these claims all recite forming a seed layer on the diffusion barrier layer.

Applicant therefore respectfully requests that the rejection of claims 1, 3-5, 7-11, and 36-45 under 35 U.S.C. § 103(a) be withdrawn.

2. Second Claim Rejection Under 35 U.S.C. § 103(a)

Dependent claims 2, 6, and 12-15 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the Xu '461 patent in view of the Xu '721 patent, and further in view of U.S. Patent No. 5,869,395 to Yim (hereinafter the "Yim patent"). Applicant respectfully traverses.

Claims 2, 6, and 12-15 depend from claim 1 and thus incorporate the limitations thereof. As discussed above, there would have been no motivation to combine the teachings of the Xu '461 patent and the Xu '721 patent. Thus, the further combination of the teachings of the Yim patent would fail to achieve the claimed invention. As such, claims 2, 6 and 12-15 are distinguishable over the cited references for at least the same reasons as discussed above with respect to claim 1.

Accordingly, claims 2, 6, and 12-15 would not have been obvious over the cited references, and Applicant respectfully requests that the rejection of these claims under 35 U.S.C. § 103(a) be withdrawn.

3. Third Claim Rejection Under 35 U.S.C. § 103(a)

The following claims:

independent claim 16, and dependent claims 17-22;

independent claim 23;

independent claim 24, and dependent claims 25-27;

independent claim 28;

independent claim 57, and dependent claims 58-61; and

independent claim 62, and dependent claim 63

stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the Xu '461 patent in view of the Xu '721 patent and the Yim patent. Applicant respectfully traverses.

Applicant reasserts the teachings of the Xu '461 patent and Xu '721 patent discussed above. Specifically, Applicant emphasizes that the Xu '461 patent teaches away from the use of a seed layer when filling very small openings in interconnect structures. Thus, the combination of the Xu '461 patent and Xu '721 patent is improper, and the further combination of the teachings of the Yim patent would fail to achieve the claimed invention. Since independent claims 16, 23, 24, 28, 57 and 62 all recite depositing or forming "a seed layer," these claims and the claims dependent therefrom would not have been obvious over the cited references. Applicant therefore respectfully requests that the rejection of claims 16-28 and 57-63 under 35 U.S.C. § 103(a) be withdrawn.

4. Fourth Claim Rejection Under 35 U.S.C. § 103(a)

Independent claim 46 and dependent claim 47 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the Xu '461 patent in view of the Yim patent. Applicant respectfully traverses.

Applicant reasserts the teachings of the Xu '461 patent discussed above. Specifically, Applicant emphasizes that the Xu '461 patent teaches away from the use of a seed layer when filling very small openings in interconnect structures. The Yim patent also does not teach or suggest the use of a seed layer. In contrast, independent claim 46 now recites "forming a seed layer upon the diffusion barrier layer." As such, Applicant respectfully submits that the Xu '461 patent and Yim patent do not by themselves or in combination teach all of the limitations of independent claim 46.

Accordingly, claims 46 and 47 would not have been obvious over the cited references, and Applicant respectfully requests that the rejection of these claims under 35 U.S.C. § 103(a) be withdrawn.

5. Fifth Claim Rejection Under 35 U.S.C. § 103(a)

The following claims:

dependent claims 48-53;

independent claim 54, and dependent claims 55-56;

stand rejected under 35 U.S.C. § 103(a) as being unpatentable over the Xu '461 patent in view of the Yim patent and further in view of the Xu '721 patent. Applicant respectfully traverses.

Applicant reasserts the teachings of the Xu '461 patent discussed above. Specifically, Applicant emphasizes that the Xu '461 patent teaches away from the use of a seed layer when filling

very small openings in interconnect structures. In contrast, independent claim 46 from which claims 48-53 depend, and independent claim 54 recite "forming a seed layer." The Yim patent also does not teach the use of a seed layer, and as discussed previously, the combination of the Xu '461 patent and Xu '721 patent is improper.

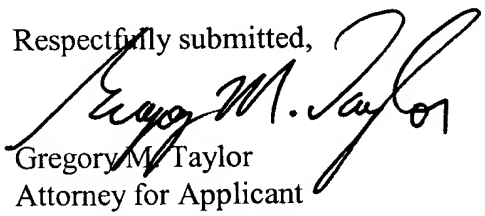
Accordingly, claims 48-56 would not have been obvious over the cited references, and Applicant respectfully requests that the rejection of these claims under 35 U.S.C. § 103(a) be withdrawn.

CONCLUSION

In view of the foregoing, Applicant respectfully requests favorable reconsideration and allowance of the pending claims. In the event the Examiner finds any impediment to the prompt allowance of this application that could be clarified by a telephone interview, the Examiner is respectfully requested to contact the undersigned attorney.

Dated this 13th day of January 2003.

Respectfully submitted,



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VERSION WITH MARKINGS TO SHOW THE CHANGES MADE

IN THE CLAIMS:

Claims 46 and 48-56 have been amended as follows:

46. (Thrice Amended) A method for manufacturing an interconnect structure, the method comprising:

forming a dielectric material over a semiconductor substrate and having a top surface;

forming a recess within the dielectric material extending from the top surface of the dielectric material to the semiconductor substrate;

filling the recess with an electrically conductive material, wherein filling the recess with the electrically conductive material further comprises:

forming a diffusion barrier layer in contact with the semiconductor substrate and the dielectric material;

forming a seed layer upon the diffusion barrier layer and composed of a material having a melting point less than that of the material from which the diffusion barrier layer is composed and being selected from a group consisting of ceramics, metallics, and intermetallics;

forming a conductor layer upon the seed layer including the portion of the seed layer within said recess; and

forming an energy absorbing layer on the conductor layer that is composed of a material having both a higher thermal insulation capacity and electric insulation capacity than that of the material from which the conductor layer is composed;

wherein the recess includes [including]:

a first portion having an uniform width and extending within the dielectric material to the top surface of the dielectric material;

a second portion having a height and a uniform width that is less than the width of the first portion and that is not greater than 25% of the height, the second portion extending from the semiconductor substrate to terminate at the first portion; and

wherein the filling the recess is performed by causing the electrically conductive material to flow within the recess by applying omnidirectional heating.

48. (Thrice Amended) The method as defined in Claim 46, wherein filling the recess with the electrically conductive material by applying omnidirectional heating [further comprises:

forming a diffusion barrier layer in contact with the semiconductor substrate and the dielectric material;

forming a seed layer upon the diffusion barrier layer and composed of a material having a melting point less than that of the material from which the diffusion barrier layer is composed and being selected from a group consisting of ceramics, metallics, and intermetallics;

forming a conductor layer upon the seed layer including the portion of the seed layer within said recess; and

forming an energy absorbing layer on the conductor layer that is composed of a material having both a higher thermal insulation capacity and electric insulation capacity than that of the material from which the conductor layer is composed;

wherein the omnidirectional heating] is performed with a furnace.

49. (Once Amended) The method as defined in Claim 46 [48], wherein the diffusion barrier layer is upon the top surface of the dielectric material.

50. (Once Amended) The method as defined in Claim 46 [48], wherein the diffusion barrier layer is composed of a material selected from the group consisting of aluminum nitride, tungsten nitride, titanium nitride, and tantalum nitride.

51. (Once Amended) The method as defined in Claim 46 [48], wherein the seed layer is composed of a material selected from the group consisting of aluminum, titanium nitride, titanium, and titanium aluminide.

52. (Once Amended) The method as defined in Claim 46 [48], wherein the conductor layer is composed of a material selected from the group consisting of aluminum and copper.

53. (Once Amended) The method as defined in Claim 46 [48], wherein the material from which the energy absorbing layer is composed is selected from the group consisting of titanium, titanium nitride, tungsten, tungsten nitride, silicon nitride, silicon dioxide, tantalum, tantalum nitride, and carbon.

54. (Twice Amended) A method for manufacturing an interconnect structure, the method comprising:

forming a lower substrate situated on a semiconductor substrate assembly, said lower substrate defining a plane;

forming a dielectric material on the lower substrate having a planar top surface;

forming a recess within said dielectric material, said recess including a contact hole situated below a trench, said contact hole terminating at an end thereof at the lower substrate and terminating at an opposite end thereof at said trench, said contact hole being oriented substantially perpendicular to the plane of said lower substrate, said trench extending from said opposite end of said contact hole to a top surface of said dielectric material, the trench

extending substantially parallel to the plane of said lower substrate; and

forming an electrically conductive layer situated within and filling both the contact hole and the trench and extending to terminate above the planar top surface of the dielectric material;

wherein the filling both the contact hole and the trench is performed by causing the electrically conductive layer to flow into the contact hole and the trench by applying omnidirectional heating; and

wherein forming the electrically conductive layer comprises:

forming a diffusion barrier layer in contact with the lower substrate and the dielectric material;

forming a seed layer upon the diffusion barrier layer and composed of a material having a melting point less than that of the material from which the diffusion barrier layer is composed and being selected from a group consisting of ceramics, metallics, and intermetallics;

forming a conductor layer upon the seed layer; and

forming an energy absorbing layer on the conductor layer that is composed of a material having both a higher thermal insulation capacity and electric insulation capacity than that of the material from which the conductor layer is composed.

55. (Twice Amended) The method as defined in Claim 54, wherein forming an electrically conductive layer by applying omnidirectional heating to cause the electrically conductive layer to flow into the contact hole and the trench [further comprises:

forming a diffusion barrier layer in contact with the lower substrate and the dielectric material;

forming a seed layer upon the diffusion barrier layer and composed of a material having a melting point less than that of the material from which the diffusion barrier layer is composed and being selected from a group consisting of ceramics, metallics, and intermetallics;

forming a conductor layer upon the seed layer; and

forming an energy absorbing layer on the conductor layer that is composed of a material having both a higher thermal insulation capacity and electric insulation capacity than that of the material from which the conductor layer is composed;

wherein the omnidirectional heating] is performed with a furnace.

56. (Once Amended) The method as defined in Claim 54 [55], wherein the contact hole has a height and a width, and the height is greater than four times the width.